Cells and Heredity

7-2 The student will demonstrate an understanding of the structure and function of cells, cellular respiration, and heredity. (Life Science)

7-2.1 Summarize the structures and functions of the major components of plant and animal cells (including the cell wall, the cell membrane, the nucleus, chloroplasts, mitochondria, and vacuoles).
Taxonomy level: 2.4-B Understand Conceptual Knowledge

Previous/Future knowledge: In 5th grade (5-2.1), students recalled that the smallest unit of life was the cell and identified its major structures (including cell membrane, cytoplasm, nucleus, and vacuole). In 6th grade (6-2.1), students summarized the characteristics that all organisms share (including the obtainment and use of resources for energy). In high school Biology, students will study the cell theory, other cell structures not listed here, and compare prokaryotic and eukaryotic cells.

It is essential for students to know that a *cell* is the smallest unit of life that conducts all life functions.

- Each cell has major structures (*organelles*) within it that perform these life functions.
- Many organelles are too small to be seen without the aid of a *microscope*.
- Cells in organisms vary in size and shape, but contain most of the same major parts.

Some structures and their functions include:
Cell membrane

- The thin, flexible outer covering of a cell. It controls what enters and leaves a cell.
- *Diffusion* is one way in which materials (for example molecules of sugar or water) move across the cell membrane. It occurs as materials are moved from an area of higher concentration to an area of lower concentration.
- *Osmosis* is the diffusion of water across a membrane.

NOTE TO TEACHER: The term *molecule* is used in biology to represent the smallest particle of a substance that still has the properties of that substance. For example, the smallest particle of a sugar compound is known as a molecule of sugar.

Cytoplasm

- The gel-like fluid inside of a cell made of mostly water.
- The other organelles are embedded in the cytoplasm.

Nucleus

- Contains the genetic material (DNA) and is the control center of the cell.

Vacuole

- Act as temporary storage centers.
- Some store water; others store waste products until they can be eliminated from the cell.

Chloroplasts

- Are the sites where photosynthesis takes place in a plant cell.
- They contain the chlorophyll used to make food.

Mitochondria
- Are the energy producing sites in the cell where respiration takes place.
- It is sometimes called the "powerhouse" of the cell.

Cell wall
- Provides support and shape for plant cells. It is made mostly of cellulose.

It is not essential that students know endoplasmic reticulum, Golgi bodies, lysosomes, or ribosomes; active and passive transport across the cell membrane.

Assessment Guidelines:
The objective of this indicator is to *summarize* the structures and functions of the major components of plant and animal cells; therefore, the primary focus of assessment should be to generalize the main points regarding the major functions of the cell structures (including cell wall, the cell membrane, the nucleus, chloroplasts, mitochondria, and vacuoles). However, appropriate assessments should also require students to *identify* individual parts of the cell or their functions; *illustrate* parts of the cell using words, pictures, or diagrams; *classify* the cell structures as either a structure in an animal cell or a plant cell; or *explain* the processes of diffusion and osmosis.

Cells and Heredity

7-2 The student will demonstrate an understanding of the structure and function of cells, cellular respiration, and heredity. (Life Science)

7-2.2 Compare the major components of plant and animal cells.
Taxonomy level: 2.6-B Understand Conceptual Knowledge

Previous/Future knowledge: In 5th grade (5-2.1), students recalled that the smallest unit of life was the cell and identified its major structures (including cell membrane, cytoplasm, nucleus, and vacuole). In 6th grade students learned about plants and animals but not their cells. Students have not studied the major differences between plants and animals at the cellular level. More detail of cell structures and processes will be a part of high school biology classes.

It is essential for students to know that even though all living organisms are made of cells that contain similar structures, there are differences between the structures of the cells of plants and animals.

- Structures that are common to plant and animal cells are the cell membrane, nucleus, mitochondria, and vacuoles.
- Structures that are specific to plants are the cell wall and chloroplasts.

Major structural differences between a plant and an animal cell include:

- Plant cells have a cell wall, but animal cells do not. Cell walls provide support and give shape to plants.
- Plant cells have chloroplasts, but animal cells do not. Chloroplasts enable plants to perform photosynthesis to make food.
- Plant cells usually have one or more large vacuole(s), while animal cells have smaller vacuoles, if any are present. Large vacuoles help provide shape and allow the plant to store water and food for future use. The storage function plays a lesser role in animal cells, therefore the vacuoles are smaller.

It is not essential for students to know other organelles in plant and animal cells or to know the chemical processes that occur within the cell parts.

Assessment Guidelines:
The objective of this indicator is to *compare* the major components of plant and animal cells; therefore, the primary focus of assessment should be to detect how the plant and animal cells structures are similar and different. However, appropriate assessments should also require students to *identify* the component parts of plant and animal cells; *exemplify* cell parts that perform specific functions in either plant or animal cells; *illustrate* plant and animal cells to indicate cell structures in each type of cell using pictures, words, or diagrams; or *classify* cells as either plant or animal based on their cell parts.

Cells and Heredity

7-2 The student will demonstrate an understanding of the structure and function of cells, cellular respiration, and heredity. (Life Science)

7-2.3 Compare the body shapes of bacteria (spiral, coccus, and bacillus) and the body structures that protists (euglena, paramecium, amoeba) use for food gathering and locomotion.
Taxonomy level: 2.6-B Understand Conceptual Knowledge

Previous/Future knowledge: In 5th grade (5-2.4), students identified the roles of organisms in an ecosystem (including microorganisms and bacteria). In 6th grade (6-2.1), students recognized the structure of classification (including the five kingdoms).

It is essential for students to know bacteria by their shape and protists (euglena, paramecium, amoeba), by the way they move and gather food.

Bacteria are organisms that are classified into the Moneran Kingdom. They are all single-celled organisms. They are classified by their body shapes.

Spiral Spiral-shaped bacteria are corkscrew shaped

Bacillus Rod-shaped bacteria

Coccus Round-shaped bacteria

Protists are organisms that are classified into the Kingdom Protista. Although there is a lot of variety within the protists, they do share some common characteristics. Protists are usually one-celled organisms that live in all moist environments. They vary in the way they obtain food and move. Examples of protists include euglena, paramecium, and amoeba.

Euglena—Protist with Flagella
- These protists move pulling themselves with long whip like structure called *flagella*.
- These protists can have one or more flagella that help them move.
- The euglena is unique in that it has characteristics of both a plant and an animal, it contains chloroplasts that photosynthesize and also can consume other organisms as well.

Paramecium—Protist with Cilia
- These protists move by beating tiny hair-like structures called *cilia.*
- The cilia act as tiny oars that allow the protist to move through its watery environment.
- The cilia also move and help to capture food directing in toward a groove that functions like a mouth.

Amoeba—Protist with Pseudopods
- These protists move by extending their bodies forward and then pulling the rest of their bodies forward as well.
- The finger-like structures that they project forward are called *pseudopods* (false foot).
- The pseudopods are also used to trap food.

Cells and Heredity

7-2 The student will demonstrate an understanding of the structure and function of cells, cellular respiration, and heredity. (Life Science)

It is not essential for students to know other types of protists or other characteristics of bacteria.

Assessment Guidelines:
The objective of this indicator is to *compare* the body shapes of bacteria; therefore, the primary focus of assessment should be to detect differences among the shapes of bacteria (spiral, coccus, and bacillus). However, appropriate assessments should also require students to *classify* a bacterial cell as spiral, coccus, or bacillus.

Another objective of this indicator is to *compare* the body structures of protists used for food gathering and locomotion; therefore, the primary focus of assessment should be to detect similarities and differences among the structures of protists (euglena, paramecium, and amoeba) used for food obtainment and locomotion. However, appropriate assessments should also require students to *identify* a protist as a euglena, amoeba, or paramecium based on its structures for food gathering or locomotion.

NOTE TO TEACHER: This may be a good place to introduce viruses. Even though viruses are only tested related to diseases (7-3.4), students will need basic knowledge of viruses.

- Viruses are tiny particles much smaller than bacteria and can only be seen with a very powerful microscope.
- In isolation, viruses show none of the expected signs of life. They do not respond to stimuli, they do not grow; they do not do any of the things we normally associate with life. Therefore, they should not be considered as living organisms at all.
- However, viruses do show one of the most important signs of life: the ability to reproduce.
- Viruses are considered to be nonliving until they infect the cells of a host plant or animal and reproduce within those cells.
- Viruses are responsible for causing many diseases in living organisms (for example AIDS, colds, and flu in humans).

Cells and Heredity

7-2 The student will demonstrate an understanding of the structure and function of cells, cellular respiration, and heredity. (Life Science)

7-2.4 Explain how cellular processes (including respiration, photosynthesis in plants, mitosis, and waste elimination) are essential to the survival of the organism.
Taxonomy level: 2.7-B Understand Conceptual Knowledge

Previous/Future knowledge: In 6th grade (6-2.7), students have received previous instruction concerning respiration and photosynthesis. Students will study in greater detail the cellular processes of organisms as part of high school Biology.

It is essential for students to know that because a cell is the smallest unit of life, it must undergo certain cellular processes in order to ensure the survival of the organism as a whole. Some of the cellular processes that are essential include:

Photosynthesis
- Plants use light energy (for example sunlight) to combine carbon dioxide (CO_2) and water (H_2O) to make simple sugars ($C_6H_{12}O_6$).
- Plant cells also release oxygen gas (O_2).
- Once the sugars are formed, they are either used by the plant or stored in the vacuoles.
- Photosynthesis occurs in the chloroplasts.

Respiration
- All organisms, including plants and animals, break down simple sugars ($C_6H_{12}O_6$) into carbon dioxide (CO_2) and water (H_2O) and release energy.
- The cell uses the energy to build, repair, and reproduce cells.
- Respiration occurs in the mitochondria of cells.

Waste elimination
- Organisms rid the cells of waste products that could be harmful to the cell.
- As waste particles accumulate in a cell, the waste will move out of the cell and be eliminated.
- The waste particles will move from a more concentrated area to a less concentrated area.

Mitosis
- Cell reproduction is called *mitosis* and occurs in the nucleus of the cell.
- Mitosis enables a cell to make an exact copy of it.
- Mitosis is a process of cell division, which results in the production of two daughter cells from a single parent cell.
- The daughter cells are identical to one another and to the original parent cell.
- Mitosis is needed for growth, replacement, and asexual reproduction.

It is not essential for students to know the stages of mitosis or meiosis, active or passive transport, or endocytosis and exocytosis.

Cells and Heredity

7-2 The student will demonstrate an understanding of the structure and function of cells, cellular respiration, and heredity. (Life Science)

Assessment Guidelines:

The objective of this indicator is to *explain* how cellular processes are essential to the survival of the organism; therefore, the primary focus of assessment should be to construct a cause-and-effect model of how the cell processes including respiration, photosynthesis in plants, mitosis, and waste elimination ensure the survival of the organism. However, appropriate assessments should also require students to *compare* and *illustrate* the processes of photosynthesis and respiration; *identify* and *recall* the functions of the cellular processes listed in the indicator; or *summarize* the ways that these processes affect cellular survival.

Cells and Heredity

7-2 The student will demonstrate an understanding of the structure and function of cells, cellular respiration, and heredity. (Life Science)

7-2.5 Summarize how genetic information is passed from parent to offspring by using the terms genes, chromosomes, inherited traits, genotype, phenotype, dominant traits, and recessive traits.
Taxonomy level: 2.4-B Understand Conceptual Knowledge

Previous/Future knowledge: Students have had no previous instruction in genetics, but they were introduced to inherited characteristics in 4th grade (4-2.4). In 6th grade (6-3.7), students compared learned to inherited behaviors in animals. Students will study in greater detail DNA and RNA and how these substances function and are replicated as part of high school biology.

It is essential for students to know that offspring may have the same physical characteristics, or *traits*, as their parents because genetic information (DNA) is passed from parent to offspring during sexual reproduction.

- Each sex cell (egg or sperm) of the parent organism (plant or animal) contains one-half of the genetic material needed to create a new organism.
- *Heredity* is the passing of traits from one generation to another, or *inheritance*.

Chromosomes

- A structure found in the nucleus of a cell that contains the genetic information (DNA).

Genes

- A segment of DNA found on a chromosome that determines the inheritance of a particular trait.
- Genes are responsible for the inherited characteristics that distinguish one individual from another.
- Genes for a specific trait generally come in pairs.
- One gene from the pair is called an *allele*.
- Genes may be expressed in two different forms.
    - *Genotype*—the set of genes carried by the organism.
    - *Phenotype*—the physical expression of the genes.

Inherited traits

- Characteristics that are passed from parent to offspring. Examples of inherited traits may be eye color, eye shape, hair type, or face shape.
- Some inherited traits are dominant and some are recessive.
    - *Dominant trait*—A trait that will always be expressed in the phenotype. Alleles for dominant traits are represented by capital letters.
    - *Recessive trait*—A trait that will only be expressed in the phenotype if two recessive alleles are present. In the presence of a dominant trait, the recessive trait will not be expressed. Alleles for recessive traits are represented by lowercase letters.

Cells and Heredity

7-2 The student will demonstrate an understanding of the structure and function of cells, cellular respiration, and heredity. (Life Science)

It is not essential for students to know the stages of meiosis, or the structure of DNA and RNA. Sex-linked traits, mutations, incomplete dominance, codominance, polygenic inheritance, and genetic engineering are also not essential concepts for this indicator.

Assessment Guidelines:
The objective of this indicator is to *summarize* how genetic information is passed from parent to offspring; therefore, the primary focus of assessment should be to generalize the major points about inheritance using the terms genes, chromosomes, inherited traits, genotype, phenotype, dominant traits, and recessive traits. However, appropriate assessments should also require students to *identify* the main components of genetic information; *explain* how genetic information passed from parents to offspring determines inheritance; or *compare* genotype and phenotype or dominant and recessive traits.

Cells and Heredity

7-2 The student will demonstrate an understanding of the structure and function of cells, cellular respiration, and heredity. (Life Science)

7-2.6 Use Punnett squares to predict inherited monohybrid traits.
Taxonomy level: 3.2-C Apply Procedural Knowledge

Previous/Future knowledge: Students have received no previous instruction in the use of Punnett squares. Students should have a beginning level of understanding of genetics and dominant and recessive genes.

It is essential for students to know that offspring inherit the genes for particular traits from their parents.

- Genes for a particular trait normally come in pairs.
- Since each parent normally has two alleles for a single trait, we use a Punnett square to determine the possibilities of the combinations of alleles that the offspring may receive.
- A *Punnett square* is a tool used to predict the ratio or percentage of the possible genes that an offspring will have based on the genes of the parent.

In a Punnett square, the top of the table shows the alleles provided by one parent.

- The alleles for the other parent are placed along the left side of the table.
- One allele from each parent is placed in the individual squares, forming a new gene pair.
- The individual squares show the possibilities of allele pairs in the offspring.
- For example, the following table shows the cross Tt x tt:

	t	t
T	Tt	Tt
t	tt	tt

- In this example, tallness (T) is the dominant trait and shortness (t) is the recessive trait.
- As the Punnett square shows, TT, Tt, and tt are all possible genotypes for the height of the offspring.
- The offspring with the genotypes TT and Tt will have a phenotype of tall; the offspring with the genotype of tt will have a phenotype of short.
- If the two alleles are the same (TT or tt), the genotype is considered *purebred*. If the two alleles are different (Tt), the genotype is considered *hybrid*.
- This example shows the inheritance of a single characteristic (height). A cross that shows the inheritance of a single characteristic is known as a *monohybrid cross*.
- It is sometimes difficult to predict certain traits in humans (for example hair color or eye color) because there may be several different genes that control these traits.

Cells and Heredity

7-2 The student will demonstrate an understanding of the structure and function of cells, cellular respiration, and heredity. (Life Science)

It is not essential for students to know how to use Punnett squares to show incomplete dominance or multiple traits. Pedigree charts are also not essential.

Assessment Guidelines:
The objective of this indicator is to *use* Punnett squares to predict inherited monohybrid traits; therefore, the primary focus of assessment should be to apply procedural knowledge of a Punnett square to determine the possible inheritance of one trait. However, appropriate assessments should also require students to *interpret* some basic information on a Punnett square; *compare* allele combinations that would relate to different genetic predictions; or *predict* the ratio or probability of traits.

Cells and Heredity

7-2 The student will demonstrate an understanding of the structure and function of cells, cellular respiration, and heredity. (Life Science)

7-2.7 Distinguish between inherited traits and those acquired from environmental factors.
Taxonomy level: 4.1-B Analyze Conceptual Knowledge

Previous/Future knowledge: Students have previously learned about inherited and acquired or learned behaviors in fourth grade (4-2.4) and sixth grade (6-3.7).

It is essential for students to know that all characteristics that organisms have are inherited from their parents but some can be influenced by environmental factors.

An *inherited trait* is a genetically determined characteristic that distinguishes one organism from another organism. Some inherited traits are dominant, some are recessive, and some are neither.

- An example of an inherited trait in plants may be color of flowers. The color red is dominant over the recessive color white. Pink flowers are a result of a blending of red and white. Other examples of inherited traits may be the shape of seeds or leaves, or the height of the plant.
- An example in animals may be eye color. Brown eye color is dominant over the recessive blue eye color. Green or hazel eyes are neither dominant nor recessive. Other examples of inherited traits may be body design, baldness, blood type, or skin color.

Physical characteristics of organisms may be influenced by environmental factors. Examples of environmental factors that can alter the phenotype of an organism may be temperature, nutrients, injuries, disease, exposure to sun, or living conditions.

- Temperature, for example, may affect the number or size of leaves in plants or the color or amount of fur or thickness of skin in animals.
- Nutrients, for example, may affect the growth or seed production in plants or the weight or height in animals.
- Injuries, for example, may cause scarring in plants and animals.
- Disease, for example, may affect the number of branches in plants or body shape in animals.
- Exposure to sun, for example, may affect the color of leaves in plants or skin changes in animals.
- Living conditions, for example, may affect the leaves, roots and height in plants or the condition of fur, skin, or teeth in animals.

It is not essential for students to understand how mutations or genetic engineering cause changes in inherited characteristics, or causes of genetic disorders.

Assessment Guidelines:
The objective of this indicator is to *distinguish* between inherited traits and those acquired from environmental factors; therefore, the primary focus of assessment should be to differentiate between traits that are inherited from physical characteristics that are influenced by environmental factors. However, appropriate assessments should also require students to *exemplify* traits that would occur due to inheritance or result from environmental factors; or *summarize* major points about inherited traits and traits influenced by environmental factors.